High(er) Intensity Proton Operation

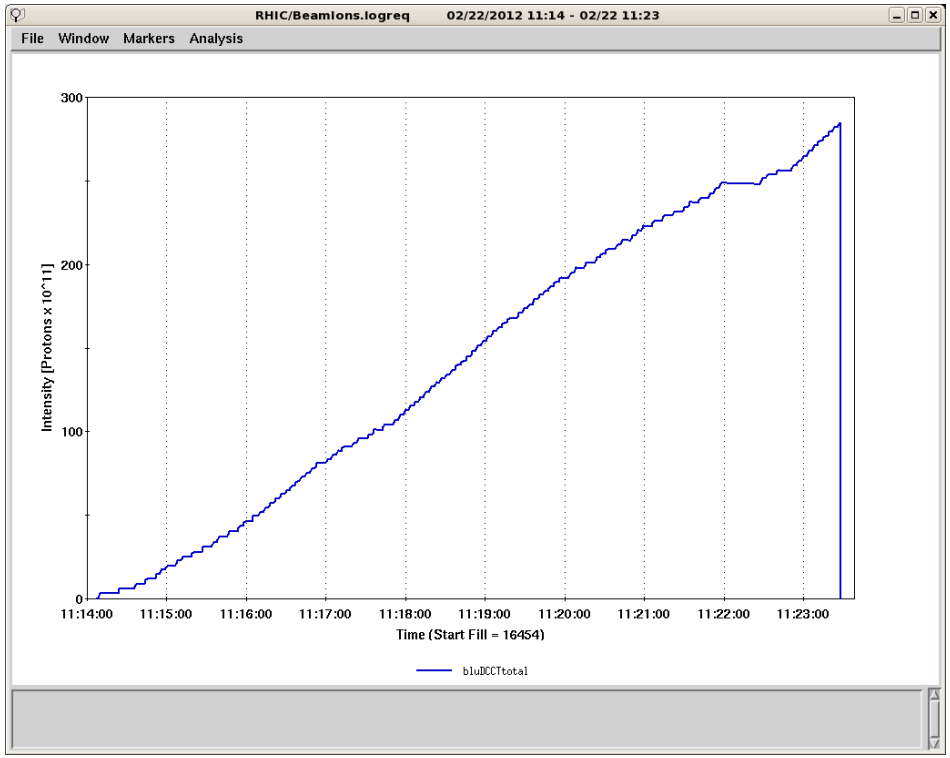
Christoph Montag

Motivation

- Electron lenses will allow for higher beam-beam parameters
- Higher intensities expected to double proton luminosity
- Goal: 3e11/bunch, with $\sigma_s = 20\,\mathrm{cm}$ bunch length
- ASE limit in Run-12 was 2.4e13 protons/beam at 250 GeV
- High intensity studies limited to injection energy

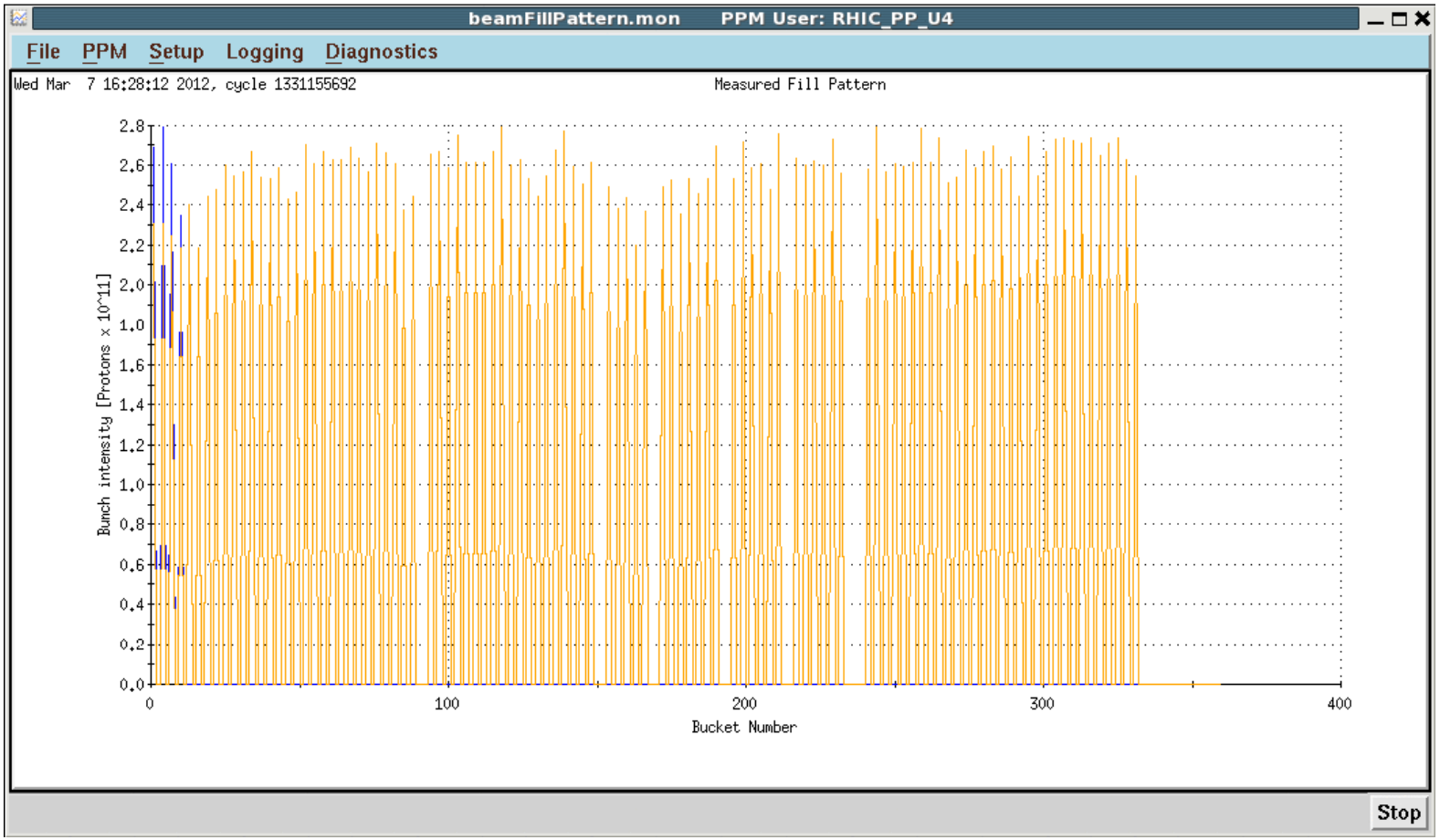
High intensity beam injection

Blue intensity



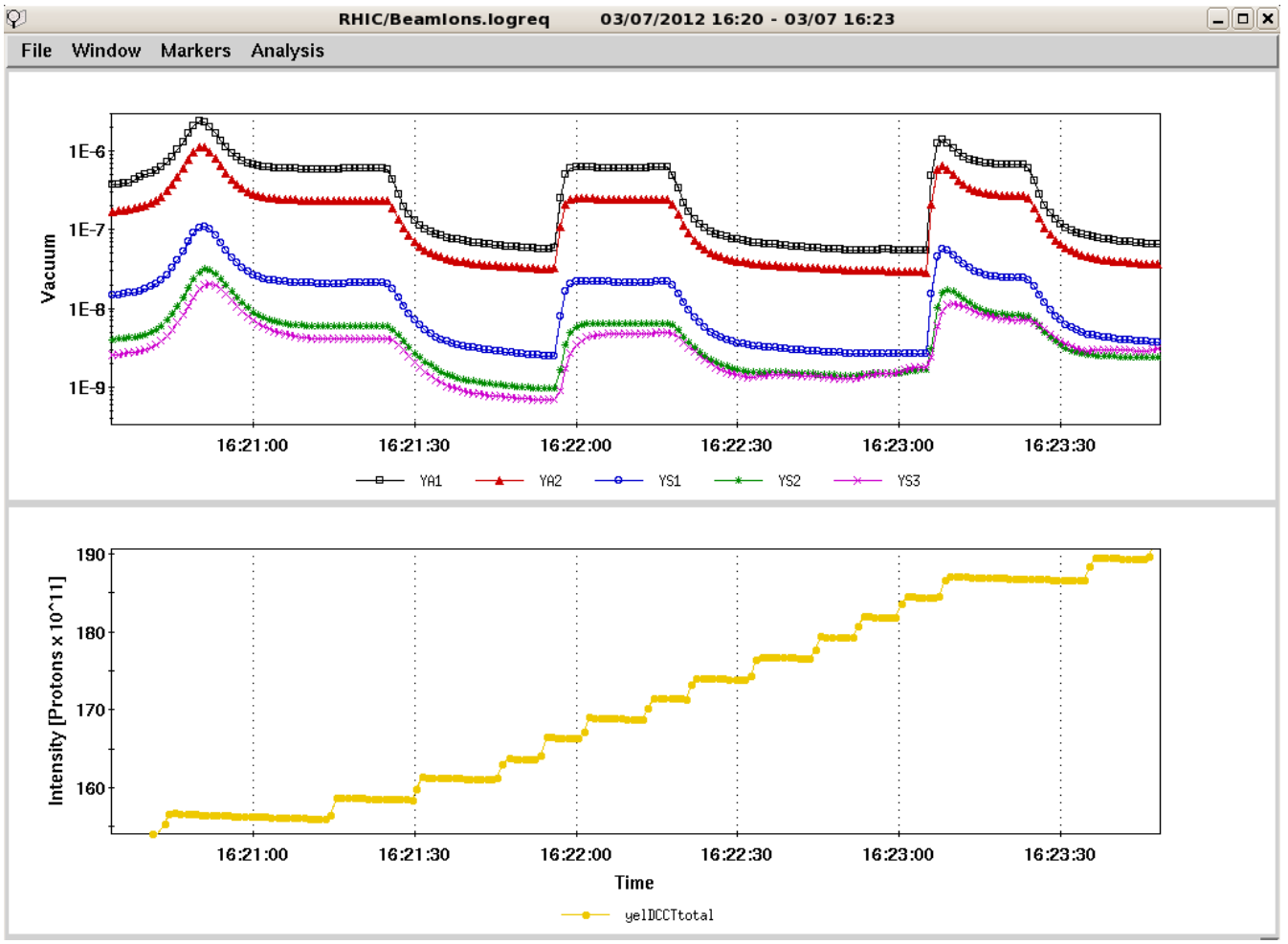
2.8e13 total in 107 bunches injected before permit was pulled by kicker smoke detector

109 high intensity bunches (2.6e11) in Yellow



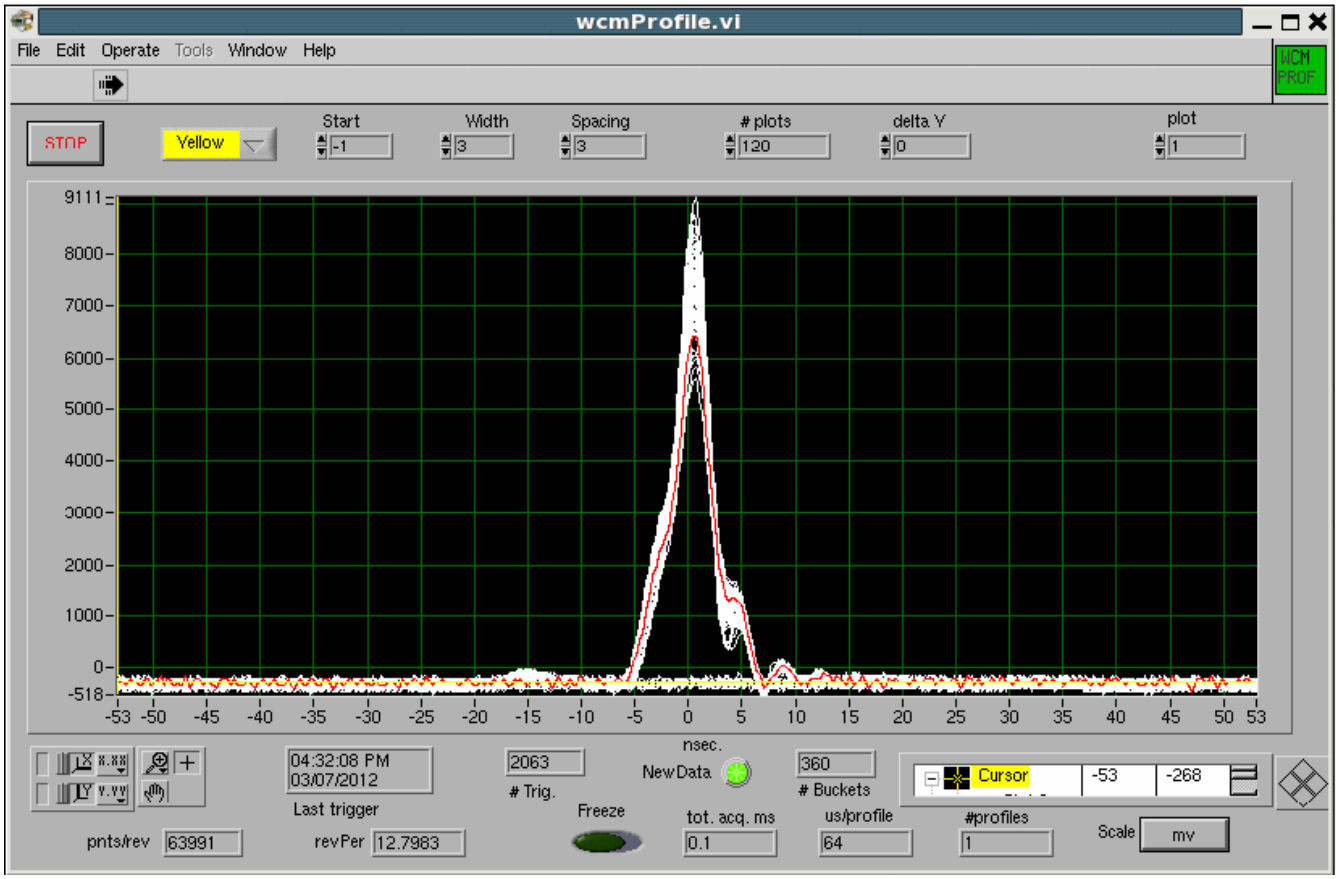
Cryo temperature rises by 20 mK, corresponding to 300 W additional cryo load - in agreement with expectations

IR4 vacuum



Vacuum during one-by-one injection of last bunches

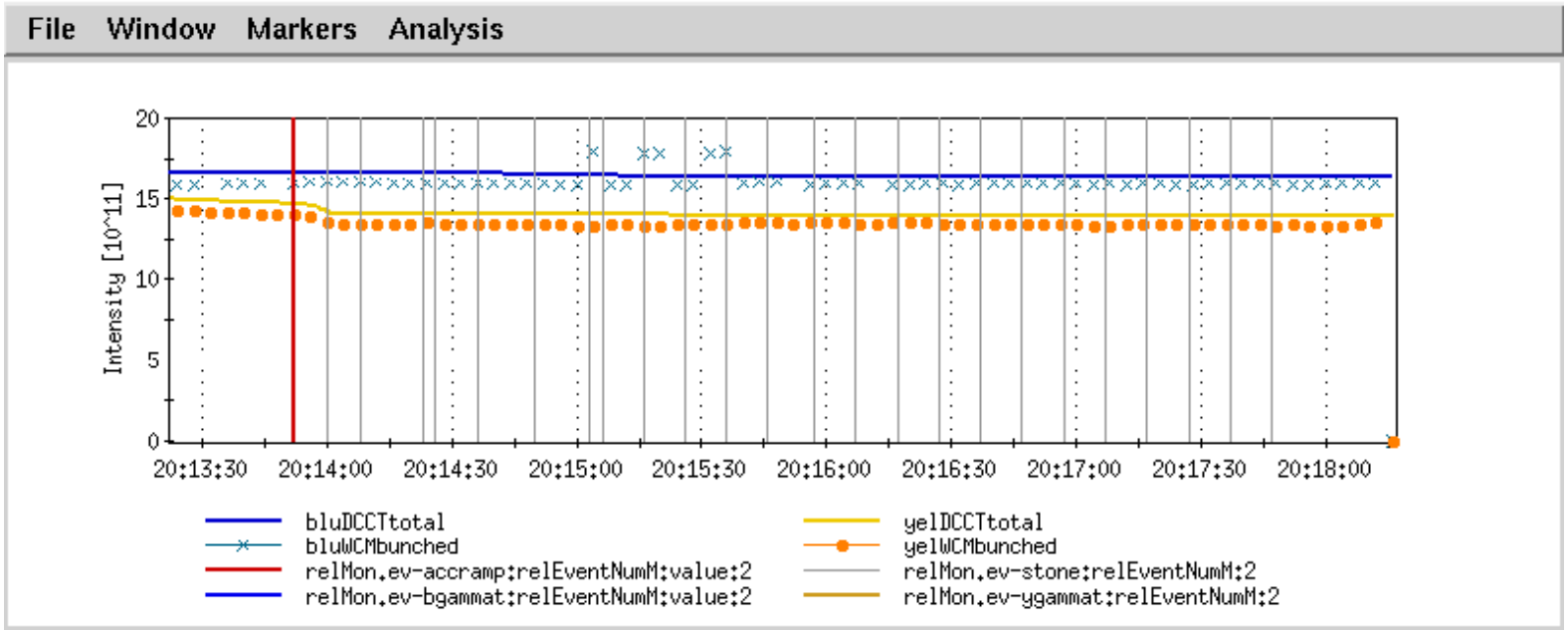
WCM profiles of 109 Yellow bunches



Approx. 2 nsec RMS, 9 A peak current

Ramping

6x6 bunch high intensity ramp



RF problems in Blue and poor injection lifetime in Yellow prevented larger bunch number

Almost 3e11 /bunch in Blue, 2.6e11 in Yellow

Good ramp transmission to 100 GeV, including rebucketing

Impedance

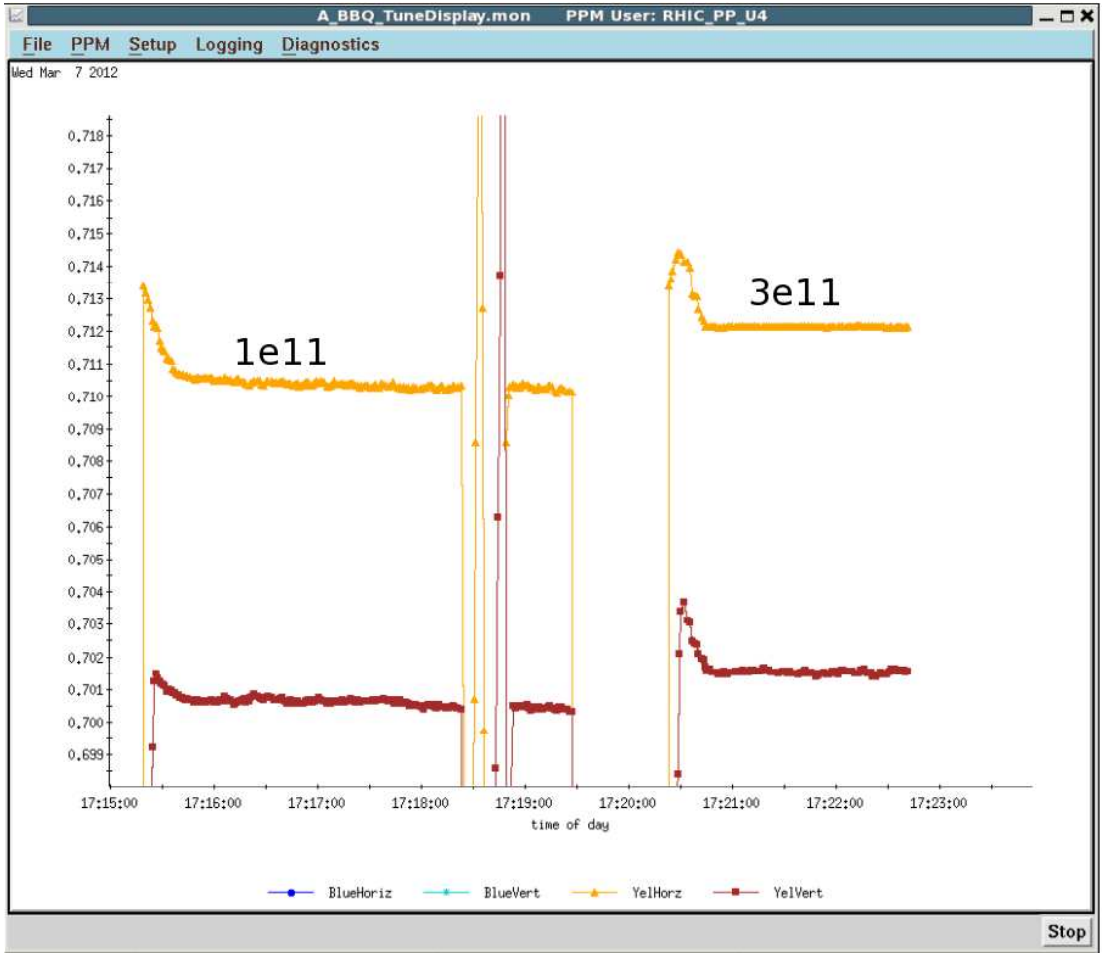
- $Z_\perp$ was measured at $3-5\,\mathrm{M}\Omega/\mathrm{m}$ in 2002. In 2010, Rama reported $18\,\mathrm{M}\Omega/\mathrm{m}$

- Measured tune of bunches with different intensities, using BTF/BBQ

- Since $\Delta Q \propto Z_\perp/(\sigma_z E)$, short bunches at injection energy give best resolution

- Required tune resolution: few 1e-4

BBQ tunes during impedance measurement



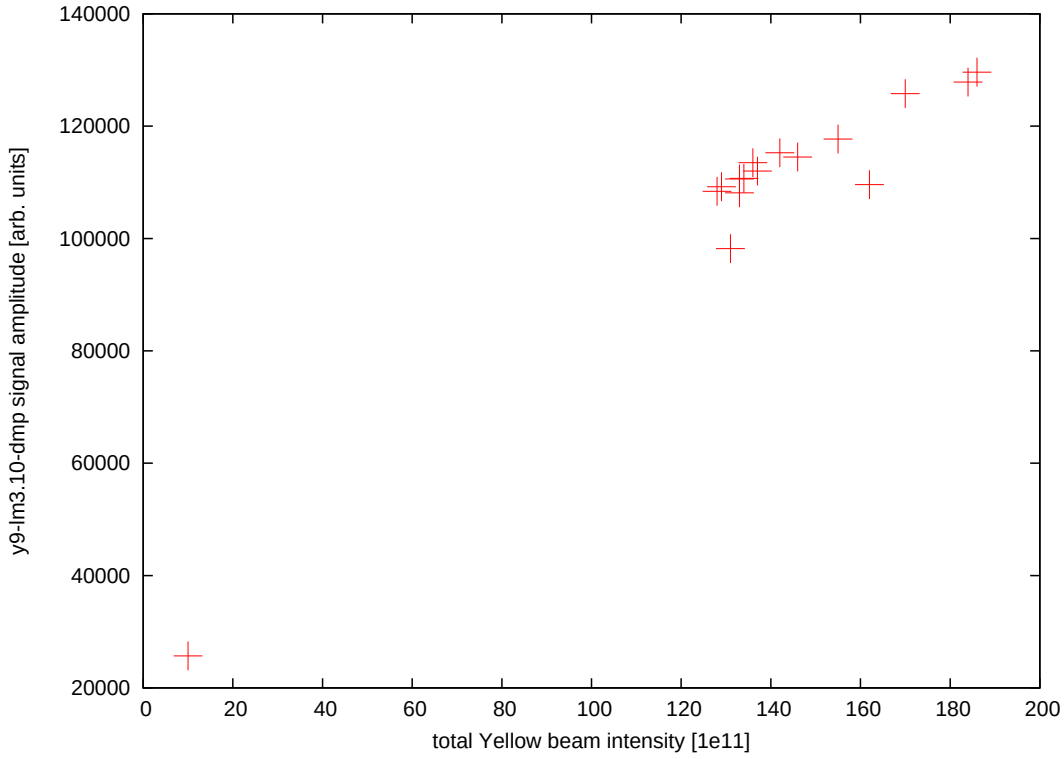
Higher intensity causes higher tunes - BBQ intensity dependence?

To be repeated using averaged ARTUS signal

Beam dump

- Beam dump was upgraded for Run-11 to avoid quenches of downstream magnets (sleeves in beam pipe)
- According to simulations, no more quenches to be expected for bunch intensities up to $\approx$ 2.5e11
- Additional BLMs were installed in a location that is relevant for those quench-causing losses
- Spent almost all the proton run on modifying theses BLMs such that they don't saturate during aborts

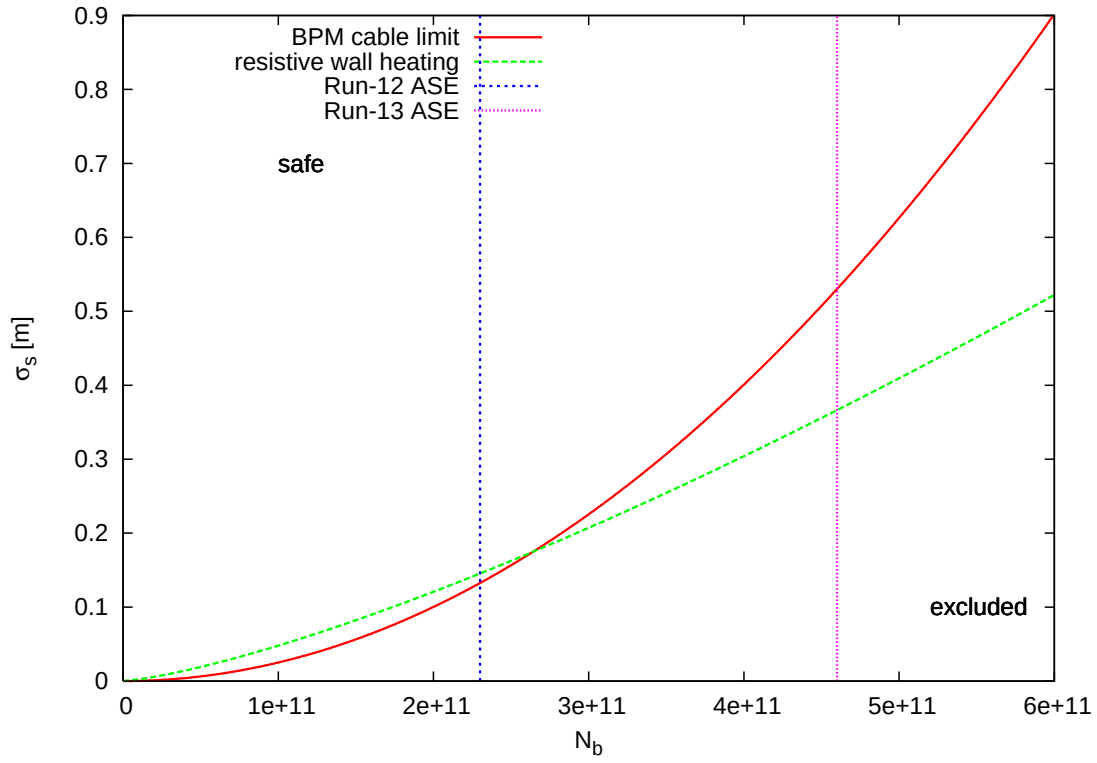
Dump BLM signals vs. intensity



BLM signal proportional to beam intensity, not saturating

Can be used now during tests to minimize losses, for instance by varying the kicker strength

Minimum allowable bunch length vs. bunch intensity



Operating with 3e11/bunch and $\sigma_s \approx 20\,\mathrm{cm}$ bunch length seems safe and feasible

Summary

- 2.6e11/bunch in 109 bunches were successfully injected - close to the goal
- Resistive wall heating agrees with expectations
- Dump BLMs are ready for systematic studies

- To be done:

  1. Impedance measurement, using averaged ARTUS signal

  2. Determine minimum chromaticity required to stabilize beams

  3. High intensity ramps, with 109 bunches (including rebucketing)

  4. Beam dump studies

  5. BPM cable heating measurements; thermocouples didn't work in Run-12